PAPERS COMMUNICATED

104. The Electron Velocity Distribution in the Celestial Gaseous Assemblies in Radiative Equilibrium.

By Yusuke HAGIHARA, M.I.A.
Astronomical Department, Tokyo Imperial University.
(Comm. Oct. 12, 1944.)

§ 1. It is known[1] that the necessary and sufficient condition for detailed balancing in a gaseous assembly consisting of atoms and light quanta is that the velocity distribution of the free particles is Maxwellian and that the distributions of the atoms in various quantum states and of the light quanta in various frequencies are respectively Boltzmann's and Planck's. In the physical state of the gaseous clouds and nebulae, such as of the planetary nebulae or of the diffuse matter in the interstellar space, the distribution of the light quanta is not Planck's and moreover, as has been shown elsewhere[2], that of the atoms in various quantum states is not Boltzmann's, so that it is not in the state of detailed balancing and hence it is not in thermodynamical equilibrium. Hence the physical condition in such gaseous assemblies ought to be sought for otherwise than in the state under laboratory conditions supposed to be in thermodynamical equilibrium. It has been shown in the previous works[3] of the present author that the extremely rarefied gaseous assemblies consisting of hydrogen atoms, hydrogen ions and free electrons, and even the assemblies containing oxygen, nitrogen and carbon in addition to hydrogen, and exposed to highly diluted high frequency radiation field, such as in the planetary nebulae, can be in a steady state in which the velocity distribution of the free electrons is not Maxwellian, although there is no transport phenomenon of particles as is usually treated in the kinetic theory of gases. The circumstance has been shown to be the same in the planetary nebulae of moderate optical thickness by solving the complicated problem of radiative transfer through the nebular layers, and the deviation of the electron velocity distribution from the Maxwellian has been seen to be moderately great according to the circumstances. It is interesting to compare this result with the theories[4] of Schrödinger,

---

1) Dirac, Proc. Roy. Soc., A **106** (1924), 581; Fowler, Statistical Mechanics, 1916, 667.

2) Hagihara, Jap. J. Astr. Geophys., **15** (1938), 1; Hagihara and Hatanaka, *ibid.*, **19** (1942), 135.

3) Hagihara, Jap. J. Astr. Geophys., **17** (1940), 199; **17** (1940), 417; **18** (1940), 89; Hagihara and Soma, *ibid.*, **18** (1941), 149; Hagihara, *ibid.*, **19** (1941), 9, 75; **20** (1943), 1. 37; Hagihara and Soma, *ibid.*, **20** (1943), 59; Soma, *ibid.*, **20** (1943), 67; also Hagihara, Monthly Notices Roy. Astr. Soc., **100** (1940), 631.

4) Schrödinger, Sitzungsber. Akad. Wiss. Wien. Math.-Phys. Kl., **121** (1912), 1305; Van Leeuwen, Journ. de Phys., **2** (1921), 374; Van Vleck, Electric and Magnetic Susceptibilities. 1932, 97; Cowling, Monthly Notices Roy. Astr. Soc., **92** (1932), 403.